Summary of ICCR Source Work Group Meeting
September 18, 1997
Internal Combustion Engines Work Group Meeting

I. Purpose

The main objectives of the meeting were to select a co-chair and alternate for the RICE WG, assess the progress of each of the subgroups and identify new tasks which need to be addressed by the work group.

II. Location and Date

The meeting was organized by the Environmental Protection Agency (EPA) and was held at the Omni Hotel in Durham, North Carolina. The meeting took place on September 18, 1997.

III. Attendees

Meeting attendees included representatives of the OAQPS Emission Standards Division, trade associations, universities, and state agencies. A complete list of attendees, with their affiliations, is included as Attachment I.

IV. Summary of Meeting

The meeting consisted of discussions between WG members on selected issues which are listed below. The order of the meeting followed the agenda provided in Attachment II. A bullet point summary of the meeting is presented as Attachment III.

The topics of discussion included the following:

- Selection of Co-Chair and Alternate
- Highlights of the Recent Coordinating Committee Meeting
- Emissions Subgroup Report on Test Plan
- Population Subgroup Report on MACT Floor
- WG Development of Recommendations to Move from MACT Floor and Test Plan to MACT Standard
- Identification of Next Steps and Formation of Subgroups
- Next Meeting

Selection of Co-Chair and Alternate

Since the request at the last WG meeting for feedback on a new co-chair and a new alternate, Amanda Agnew received no suggestions from the Work Group. Consensus was reached on Vick Newsom to continue as Work Group Co-Chair and Sam Clowney to proceed as Co-Chair Alternate.

Highlights of the Recent Coordinating Committee Meeting

Vick Newsom relayed highlights from the Coordinating Committee Meeting and the Dioxin Primer. The flash minutes for the CC Meeting and the slides for the presentation of the Dioxin Primer can be downloaded from the TTN.

One important highlight of the Dioxin Primer, pointed out by Vick Newsom, is that the information presented by Randy Seeker shows that there is very low to moderate potential for dioxin to be formed by IC engines.

A Tracking Subgroup was formed on the Coordinating Committee to track the progress of each of the source work groups. They will require a timeline of the RICE WG's activities and deadlines.

The Information Collection Request (ICR) was recently completed. Engine emission data was one aspect covered by the ICR. However, the data collected may be ambiguous, due to vague wording on the ICR form regarding HAP emissions data.

The dates for the future CC Meetings are tentatively scheduled as follows:

2/24-25	Greensboro, NC
4/28-29	Colorado
7/21-22	California
9/22-23	Raleigh, NC
12/8-9	Houston, TX

Emissions Subgroup Report on Test Plan

Sam Clowney presented a report on the RICE Test Plan drafted by the Emissions Subgroup. A copy of this presentation is included as Attachment IV. A copy of the Draft Test Plan under discussion, which was sent out prior to the meeting, is included as Attachment V. Laura Kinner of EMI also made a presentation regarding the comments received on the pollutant lists, and it is included as Attachment VI.

The topics of discussion which followed included the basis for testing, the focus of testing, the applicability of the test plan to MACT floor determination, and the pollutant list.

Basis for Testing

Amanda Agnew raised the concern that the Coordinating Committee will ask why testing is even necessary when there are existing emissions test reports available in the RICE emissions database. Sam Clowney responded that these test reports were inadequate, since they lack documentation of engine engineering parameters during testing. It was brought to a consensus that another appendix should be added to the Test Plan, giving justification for additional testing instead of using the existing data.

Focus of Testing

Bill Passie stated that the chosen engines for the Test Plan should reflect the distribution of engines in the RICE Population Database. Several WG members agreed with this statement. Ed Torres felt that the testing priority should reflect the tendencies of the MACT floor. The current number one engine to be tested in the Test Plan is a Clark TLA Turbocharged engine, which represents the 2-stroke gaseous fuel subcategory. The subcategory which currently reflects a MACT floor is four stroke rich burn gaseous fuel.

Ed Torres also disagreed with the statement under section 2.2 of the Test Plan. The wording states that “The efficiency of the control devices tested for natural gas will be achievable by the other gaseous fuels.” Ed Torres argued that catalytic control for digester gas fired engines may not be technically feasible. Fouling of the catalyst can occur at a very high rate when applied to digester gas fired engines. Other members also disagreed with the wording under section 2.2. Bryan Willson stated that the catalyst should do the same job for digester gas as for natural gas until the catalyst starts fouling. He noted that the current Test Plan does not address performance over time or fouling. Maintenance and operating issues will not be addressed in the current Test Plan. It was decided by the WG that Ed Torres should submit suggested language for section 2.2 of the Test Plan, addressing the concern about digester gas. Sam Clowney requested that Ed Torres provide data to support his statement that oxidation catalysts may not work well on units fired by digester gas. The Emissions Subgroup will determine how to modify the Test Plan once the data is reviewed.

Amanda Agnew inquired whether or not engines would be tested before and after control devices. Sam Clowney confirmed that both before and after control devices would be tested for all engines in the Test Plan.

Applicability of Test Plan to MACT Floor Determination

The priority of MACT floor determinations were presented by Reese Howle. These were as follows:

1) Set a numerical emission limit (the basis of which is a control technology). This provides greatest flexibility for all sources.

If number one is infeasible, then

2) Set a performance standard (a percent reduction in emissions across the board, regardless of the current emissions of any particular source).

If number two is also unattainable, then

3) Set a control device standard, (e.g. oxidation catalyst). This is not ideal, since regardless of the emission level, a certain control device would be added across the board for all engines in this subcategory.

Linda Coerr stated that the Emissions Subgroup developed the Test Plan to look at efficiencies of possible MACT control devices. In this sense, the current Test Plan focuses on a performance standard (the second priority stated above). If the primary focus of the WG is to set a numerical emission limit, the Test Plan's focus should be reconsidered. Linda Coerr noted that the Emissions Subgroup has not discussed the possible use of the results from the testing to set a numerical emission limit as MACT.

Pollutant List

With regards to metals, J. Darrell Bowen questioned whether fuel testing would be sufficient to account for emissions of metals from IC engines. Laura Kinner indicated that an in-stack metals test would take two to four hours to conduct, and suggested that such testing would not be practical given the operating test matrix that the WG is proposing. Laura Kinner stated that particulate matter from sources often indicates the presence of metals.

With regards to chlorinated compounds, the WG discussed the possibility that the compounds are reported in the laboratory test results due to laboratory contamination, not presence of these compounds in the IC engine exhaust. Laura Kinner noted that methylene chloride was consistently reported in the highest concentrations out of all of the chlorinated compounds. She also pointed out that methylene chloride is a common contaminant in laboratory analyses, since it is often used to clean glassware and is in the ambient air of many laboratories. Wayne Hamilton added that in his experience at Shell, the labs indicated that methylene chloride is a contaminant present in the lab and it is very difficult to keep methylene chloride from getting into any sample that is analyzed in a lab. Laura Kinner suggested that it is therefore best to use a direct interface method of analysis, such as the GC/MS, to prevent contamination from laboratories rather than the laboratory method of TO-14. A GC/MS method would draw the sample directly from the stack and analyze the sample on-site. Laura Kinner also suggested that as a compromise, the RICE WG could add methylene chloride only to the list of pollutants, since it was the greatest detected chlorinated compound. Amanda Agnew asked about the cost for testing chlorinated compounds. Laura Kinner responded that chlorinated compounds can be tested on the GC/MS at little additional cost. It is only a matter of calibrating the machine to look for these pollutants, and this cost is nominal compared to the cost of the entire test. Michael Horowitz stated that methylene chloride is the chlorinated compound of principal concern, since it is the only chlorinated compound that was reported above the detection limit in more than one test.

With regards to particulate matter, the WG discussed the use of Method 5 for detecting particulate matter. Representatives from the Engine Manufacturer's Association suggested that Method 5 is inappropriate for the Test Plan. The EMA representatives suggested that the WG consider a real-time test method, such as the Sierra or the ISO method. Laura Kinner noted that sampling for Method 5 can take several hours, which may be impractical given the operating test matrix that the WG has proposed.

Bryan Willson presented Dick Van Frank's data on mercury emissions from landfill gas fired engines. Two tests were performed on the Fresh Kills Landfill in Staten Island, New York, for mercury in June of 1996. The first report reflected emissions of roughly 300 pounds per year, and the second reflected emissions of about 2.3 pounds per year. Reasoning for this discrepancy was not explained in the reports.

Population Subgroup Report on MACT Floor

Wayne Hamilton presented a report on the Population Subgroup activities. This is included as Attachment VII. The basis for discussion was the handout that was emailed out prior to the meeting, entitled “Population Subgroup Topics to be Discussed at the September 18 Meeting,” and it is included as Attachment VIII. The topics of discussion which followed included the statistical adequacy of the data, feasibility of engine subcategorization, blanks and anomalies in the control device field, engine efficiencies, and providing the RICE Population database to the RICE WG.

Statistical Adequacy of the Data

Wayne Hamilton noted that the Population Subgroup needs assistance in determining whether the data in the Population database is representative of the existing population of engines. He suggested that one possible solution is to have an EPA or industry statistian review the database. EPA has agreed to look into this issue since it will affect all source work groups. Some WG members regarded the data in the Population Database as not representative of the real world.

Bryan Willson stated that the numbers presented in the RICE Population Database, which reflects that four stroke engines are twice as populous as two stroke engines, are inaccurate. This number should reflect that four stroke engines are ten times as populous as two stroke engines.

Charles Elder stated that Power Systems Research has a database of combustion sources, and suggested that the RICE WG compare the RICE population database with that of Power Systems Research.

It was suggested that a comparison also be performed between the API database and the RICE population database. Vick Newsom felt this would not be a good comparison, since API did not consider any engines below 150 HP. Wayne Hamilton will contact Glenda Smith of API to set up a meeting between her and Alpha-Gamma, to see how the databases compare.

Bill Passie stated that Oil and Gas Production was too highly represented in the RICE Population Database, based on numbers presented on SIC distributions.

WG members decided that a breakdown by industry for each state and a horsepower distribution by fuel type would each provide a better look at the statistical representation of the RICE Population Database. This work will be performed by Alpha-Gamma before the next WG meeting.

Feasibility of Engine Subcategorization

Many work group members voiced their opinions that it was premature to determine engine subcategories, based on the general consensus about the lack of data in the current RICE Population Database.

Vick Newsom stated that since the population numbers are not currently representative of the real world, MACT should be based on strictly liquid or gaseous fuels.

Ed Torres requested that Alpha-Gamma further subcategorize the spark ignition gaseous fuel fired engines by specific fuel type. This would assist the WG in better understanding the application of control technologies to each fuel type.

Blanks and Anomalies in the Control Device Code Field

Consensus was reached on the issue of blanks being no controls, based on the information presented in the handout emailed out prior to the meeting.

It was noted by engine manufacturers that many control devices presented from the database did not make intuitive technical sense. During lunch, Chuck Elder and Bob Stachowicz, with the consensus of the other engine manufacturers present, went through the control devices presented for spark ignition engines and marked those of which made no sense as actual control devices for reciprocating internal combustion engines.

Engine Efficiencies

Bill Passie brought up the possibility that the engine efficiencies that were used for the HP distribution/unit conversion may be inaccurate, since the numbers presented demonstrate that rich burn engines are more efficient than lean burn engines. Alpha-Gamma was assigned to research this topic before the next meeting.

Provide RICE Population Database to RICE WG

The RICE WG came to a consensus that the RICE Population database should be uploaded to the TTN by October 1st. This will be performed by Alpha-Gamma Technologies.

WG Development of Recommendations to Move from MACT Floor and Test Plan to MACT Standard

The WG had a brainstorming session on this topic. The results are listed below:

Existing Source MACT

- Determine subcategories
- Determine definition of “source”
- Identify applicable control technology and availability (Is the technology available only for certain subcategories or sizes of engines?)
- Identify possible work practices
- Develop model units to evaluate cost-effectiveness of controls and work practices
- Determine effects of controls and work practices on HAP emissions (some pollutants increase, some pollutants decrease, some stay the same)
- Determine emission reductions achievable with control technology and work practices
- Determine typical emissions for each subcategory
- Determine costs for applicable control technology
- Determine durability/life/feasibility of controls
- Determine which pollutants will be regulated under MACT
- Develop the test protocol to go with the MACT standard (baseline and as-controlled)
- Determine compliance monitoring, inspection, reporting and recordkeeping requirements
- Determine size cutoffs
- Determine national impacts - total number of regulated sources

New Source MACT

- Identify applicable control technology and availability (must be demonstrated in full-scale application)
- Determine MACT floor for new sources (best performing similar source)
- Determine if new source MACT should be equivalent to existing source MACT
- Evaluate impact of standards for criteria pollutants at time MACT is promulgated
- Define criteria for “new source” - if move an existing engine, is that a new source?
- Address pollutant tradeoffs - what is the best performing

similar source when there are multiple pollutants - is it the one with the least formaldehyde, the least PAH, or the least total HAPs?

Identification of Next Steps and Formation of Subgroups

Emissions Subgroup

Before the next meeting, the Emissions Subgroup will add three appendices to the Test Plan. These will be 1) a commentary on the review of the existing emissions database, including why additional testing is needed; 2) the test protocol; and 3) a response to comments. The Emissions Subgroup will respond in writing to issues provided by WG members, and will provide the revised Test Plan to the WG before October 30th.

Other issues of focus for the Emissions Subgroup are the following: 1)cost effectiveness, based on efficiency of controls, typical emissions, and cost of controls; and 2)identification of applicable control technologies.

Population Subgroup

Before the next meeting, the Population Subgroup will:

1. Eliminate unrealistic control devices in the RICE database
2. Draft a MACT Floor, including determination of subcategories
3. Compare the EPA database with the Power Systems Research database
4. Provide the RICE database to the WG by October 1
5. Compare the EPA database with the American Petroleum Institute database

Other issues of focus for the population subgroup will include model plants and inventories.

New Source MACT Subgroup

To address the issue of new source MACT, a new subgroup was formed, called the New Source MACT Subgroup. It will be headed by Bill Passie, and its members will include Bryan Willson and Mike Brand. The focus of this group will be to identify pollutant tradeoffs (determining the best performing similar source when there are multiple pollutants), and to identify the best existing control.

Schedule Subgroup

In order to accommodate the CC Tracking Subgroup's needs, a Schedule Subgroup was formed, headed by Amanda Agnew. Members will include the chairs for each of the other subgroups: Sam Clowney, Wayne Hamilton and Bill Passie. They will determine the timeline for all RICE WG activities, and correspond with the Tracking Subgroup of the Coordinating Committee.

Other Issues

Amanda Agnew mentioned that a Satisfaction Survey for the ICCR has been submitted for response from the entire ICCR. Work group members can submit their surveys to Amanda Agnew by September 30, 1997. This survey was provided to the WG as a handout, and is available through Amanda Agnew.

John Blair also gave notice that he can no longer serve as a RICE WG Member. Amanda Agnew pointed out that there is no longer any environmental group representation on the WG, and requested input from the WG concerning this matter.

Next Meeting

The next Internal Combustion Work Group Meeting will be in Chicago, IL on Thursday, October 30, 1997, starting at 9:00 a.m. EST. The meeting will run until 4 p.m., and there will be a working lunch. On the agenda for the next meeting are the following topics:

* Presentation by Population Subgroup on MACT floor
* Reach consensus on the subcategorization and MACT floor
* Presentation by Emissions Subgroup on Test Plan
* Reach consensus on Test Plan and appendices, (including dioxins, mercury, metals and chlorinated hydrocarbons)
* Presentation by Schedule Subgroup on timeline/Tracking Subgroup requirements
* Next Steps

These minutes represent an accurate description of matters discussed and conclusions reached and include a copy of all reports received, issued, or approved at the September 18, 1997 meeting of the Reciprocating Internal Combustion Engines Work Group.

Amanda Agnew

ATTACHMENT I

LIST OF ATTENDEES

Stationary Internal Combustion Engines Work Group Meeting
September 18, 1997
List of Attendees

Amanda Agnew	EPA OAQPS Emissions Standards Division
Alec Atanas	Englehard Corporation
Darrell Bowen	CNG Transmission Corporation
Michael Brand	Cummins Engine Co., Inc.
Sam Clowney	Tenneco Energy
Donald Dowdall	Engine Manufacturers Association
Charles Elder	General Motors Corporation
Wayne Hamilton	Shell E&P Technology Company
William Heater	Cooper Energy Services
Michael Horowitz	U.S. Environmental Protection Agency
Jed Mandel	Engine Manufacturers Association
Jay Martin	University of Wisconsin-Madison
Michael Milliet	Texaco E&P Inc.
Vick Newsom	Amoco Production Section
William Passie	Caterpillar, Inc.
Donald Price	Ventura County Air Pollution Control District
Bob Stachowicz	Waukesha Engine Division
Ed Torres	Orange County Sanitation District
Bryan Willson	Colorado State University
Jan Connery	Eastern Research Group
Reese Howle	Alpha Gamma Technologies
Jennifer Snyder	Alpha Gamma Technologies
Linda Coerr	Coerr Environmental
Jim Wright	Testing and Monitoring Protocol Work Group
Pamela Lacey	American Gas Association
Laura Kinner	EMI

Mahesh Gundappa Radian International

Jim McCarthy GRI

ATTACHMENT II

SEPTEMBER 18, 1997 MEETING AGENDA

Agenda
Reciprocating Internal Combustion Engine Work Group
September 18, 1997 WG Meeting - Durham, NC

8:00 - 8:15	Welcome, Meeting Goals (A. Agnew) Agenda Review (J. Connery) Meeting Goals: 1. Selection of Co-chair and Alternate 2. Population Subgroup: -Agreement on MACT Floor -Identification of Questions about MACT Floor that Need to be Addressed before Presentation to CC in November 3. Emissions Subgroup: -Agreement on Test Plan -Identification of Questions about Test Plan that Need to be Addressed before Presentation to CC in November
8:15 - 8:30	Selection of Co-Chair and Alternate
8:30 -8:45	Outcome of the CC Meeting (V. Newsom and A. Agnew) - Dioxin Primer as it applies to engines
8:45 - 9:00	Review of MACT Floor Timeline (W. Hamilton)
9:00 - 9:30	Emissions Subgroup Report on Test Plan and WG Feedback on Issues (S. Clowney)
9:30 -10:00	Population Subgroup Report on MACT Floor and WG Feedback on Issues (W. Hamilton)
10:00-10:15	BREAK
10:15-11:30	WG Discussion of Remaining Issues on MACT Floor and Test Plan
11:30- 12:45	LUNCH
12:45 - 2:45	WG Development of Recommendations to Move from MACT Floor and Test Plan to MACT Standard for IC Engines - Overview of ICCR Schedule for MACT Development (A. Agnew) - MACT Standard Scenarios (A. Agnew and S. Clowney) - Tools to Evaluate Scenarios and Backup Materials Required for MACT
2:45 - 3:00	BREAK
3:00 - 4:00	WG Development of Recommendations to Move from MACT Floor and Test Plan to MACT Standard for IC Engines (continued)
4:00- 4:30	WG Identification of Next Steps and Formation of New Subgroups
4:30 - 4:45	Next Meeting (A. Agnew and J. Connery) - Schedule - Tentative agenda items
4:45 - 5:00	Review of Flash Minutes (J. Connery and J. Snyder)
5:00	ADJOURN

ATTACHMENT III

BULLET POINT SUMMARY

Summary of ICCR Source Work Group Meeting, September 18, 1997
Internal Combustion Engines Work Group Meeting
Omni Hotel, Durham, NC

Decisions

- Consensus on keeping the current co-chair and alternate, Vick Newsom and Sam Clowney.
- Consensus on assuming that blanks = no control device in the Population database.
- A New Source MACT Subgroup was formed, headed by Bill Passie. Its members will include Mike Brand and Bryan Willson. Others will be recruited.
- A Schedule Subgroup was formed, headed by Amanda Agnew. Its members will include the heads of the other 3 subgroups, Bill Passie, Sam Clowney and Wayne Hamilton.
- The RICE WG will ask the Coordinating Committee to pass on ICE HAP data/emissions data collected from the Information Collection Request.

Next Meeting

- The next Internal Combustion Work Group Meeting will be held in Chicago, IL on Thursday, October 30, 1997 from 9:00 a.m. to 4:00 p.m. CST. (There will be a working lunch.)
- On the agenda for the next meeting are the following:
  *Presentation by Population Subgroup on MACT floor
  *Reach consensus on the subcategorization and MACT floor
  *Presentation by Emissions Subgroup on Test Plan
  *Reach consensus on Test Plan and appendices, (including dioxins and mercury)
  *Presentation by Schedule Subgroup on timeline/Tracking Subgroup requirements
  *Next Steps
- For Your Information:
  The 1998 CC Meetings are tentatively scheduled as follows:
  2/24-25 Greensboro, NC
  4/28-29 Colorado
  7/21-22 California
  9/22-23 Raleigh, NC
  12/8-9 Houston, TX

Action Items

- WG: feedback on ICCR Satisfaction Survey to Amanda Agnew by September 30.
- WG: keep a lookout for environmental representation for the RICE WG
- Emissions Subgroup: Add 3 appendices to the Test Plan:
  *review of database
  *test protocol
  *response to comments
  Provide this revised Test Plan to the WG by 10/30/97.

- Population Subgroup: Get rid of nonsense controls in subcategory breakdown of control devices
- Population Subgroup: Determine preliminary MACT floor (and subcategories). Provide to WG in writing by 10/23/97.
- Population Subgroup: Compare RICE Database with Power Systems Research Database.
- Population Subgroup: Provide cleaned up database to WG on TTN by 10/1/97.
- Population Subgroup: Compare RICE Database with API Database. (Glenda Smith)
- Ed Torres: Provide footnote for Section 2.2 of Test Plan regarding applicability/efficiency wording as applied to Digester Gas and Natural Gas.
- Alpha-Gamma: Check on efficiencies given for Rich Burn and Lean Burn engines
- Alpha-Gamma: Horsepower distribution by fuel type (Diesel vs. Natural Gas, and past 2/4 stroke, rich/lean burn)
- Alpha-Gamma: Provide diesel fired engine control devices to WG
- Alpha-Gamma: Provide combined Geographical and Industrial distribution to WG
- S. Clowney and A. Agnew: Determine deliverables for subgroups
- V. Newsom: Provide status report to CC by 11/3/97.

ATTACHMENT IV

REPORT ON THE RICE TEST PLAN FROM THE EMISSIONS SUBGROUP
PRESENTED BY SAM CLOWNEY

RICE Test Plan

presented to:

Reciprocating IC Engine Work Group
Durham, North Carolina

presented by:

Sam Clowney, Tennessee Gas Pipeline,
on behalf of the Emissions Subgroup

September 18, 1997

RICE Test Plan

- Components of the Test Plan:
  1. Engines, Fuels, and Emission Controls to be Tested
  2. Matrix of Operating Conditions to be Tested
  3. Pollutants to be Measured During testing
  4. Test Methods to Quantify Emissions
  5. Prioritization
- Draft Test Plan Complete
  - distributed to Work Group on Monday, September 15, 1997
  - intent of draft is to gain Work Group consensus on specifics related to 5 components of test plan
  - two appendices anticipated to address:
    - additional testing specifications and protocols
    - response to Coordinating Committee comments on pollutant lists

Goals for Test Plan

- Emissions Subgroup identified 3 possible goals:
  1. determine effectiveness of after-treatment control devices to reduce formaldehyde
  2. determine the effectiveness of combustion modifications to reduce formaldehyde
  3. determine typical emissions for engines throughout the operating range
- Draft Test Plan designed around Goal #1:
  - emissions data on control device efficiency is a data gap in the ICCR Emissions Database
  - little understanding of effects of combustion modifications on HAPs
  - EPA has endorsed the use of ICCR emissions testing dollars to achieve this goal

Engines, Fuels and Controls

- Four Tests

Engine to be Tested	Engine Subcategory	Fuel	Control Device
Clark TLA Turbocharged	2-stroke, gaseous fuel	Natural Gas	CO catalyst
Caterpillar 3500 Series Turbocharged	liquid-fuel	Diesel	CO catalyst
Waukesha 7042 GL Turbocharged	4-stroke, lean-burn, gaseous fuel	Natural Gas	CO catalyst
Ingersoll Rand KVG Naturally Aspirated	4-stroke, rich-burn, gaseous fuel	Natural Gas	NSCR 3-way catalyst

Matrix of Operating Conditions

- Four corners of torque/speed envelope (runs 1-4)
- Air-to-fuel ratio sensitivity (runs 1, 5-6)
- High speed and low load (run 7)
- Low speed and high load (run 8)
- Air manifold temperature sensitivity (runs 1, 9-10)
- Jacket water temperature sensitivity (runs 13-14)
- Engine balance sensitivity (runs 1, 15-16)

Run	Speed	Torque	Air to Fuel Ratio	Timing	Air Manifold Temperature	Jacket Water Temperature
1	H	H	N	S	S	S
2	H	L	N	S	S	S
3	L	L	N	S	S	S
4	L	H	N	S	S	S
5	H	H	L	S	S	S
6	H	H	H	S	S	S
7	H	L	H	S	S	S
8	L	H	L	S	S	S
9	H	H	N	S	L	S
10	H	H	N	S	H	S
11	H	H	N	S	S	L
12	H	H	N	S	S	H
13	H	H	N	L	S	S
14	H	H	N	H	S	S
15	H	H	N	S	S	S
16	H	H	N	S	S	S
*Notes:	H, L to be determined based on operating range and control flexibility.	H, L to be determined based on operating range and control flexibility.	N = Nominal reqd. to satisfy emissions H, L to be determined based on operating range and control flexibility.	S = Set point H, L to be determined based on operating range and control flexibility.		

Test Methods

- Methods that provide data on-site selected (when possible)
- Criteria Pollutants
  - FTIR for CO and NOx
  - EPA Method 25A for THC
  - EPA Method 5 for PM
- HAPs
  - Portable GCMS for:
    - BTEX
    - 1,3-butadiene
    - n-Hexane
  - FTIR for:
    - formaldehyde
    - acetaldehyde
    - acrolein
  - Method 429:
    - Naphthalene
    - PAHs
  - Fuel Testing for Metals:
    - Beryllium, Cadmium, Chromium, Lead, Manganese, Mercury, Nickel, Selenium

Prioritization

- Priority to testing one engine from each subcategory identified thus far

- Priority to testing those emission control devices which have been identified thus far as possible controls for MACT

Proposal for Consensus

- Emissions Subgroup proposes that:
  - The test plan for four emissions tests be approved, as proposed in the draft test plan.
  - That two appendices be added to the document to address:
    - » specifics necessary for testing contractors to estimate costs, and
    - » response to comments received on pollutant lists.
  - That the Work Group present the test plan and request funding for testing at the November Coordinating Committee.

ATTACHMENT V
DRAFT TEST PLAN

PLAN FOR EMISSIONS TESTING OF RECIPROCATING INTERNAL COMBUSTION ENGINES

presented to:

Reciprocating Internal Combustion Engine (RICE) Work Group
Industrial Combustion Coordinated Rulemaking

presented by:

Emissions Subgroup of the RICE Work Group
Industrial Combustion Coordinated Rulemaking

September 1997

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1.0 INTRODUCTION

The Reciprocating Internal Combustion Engine (RICE) Work Group has determined that additional emissions data is necessary to support the rulemaking development for RICE, as a part of the Industrial Combustion Coordinated Rulemaking (ICCR). The Work Group has developed this emissions test plan for future emissions testing (both air toxics and criteria pollutants) of stationary reciprocating internal combustion engines (RICE). The results of this test plan will provide additional emissions data and will address key data gaps that are present in the EPA ICCR Emissions Database for RICE.

1.1 . . . . Components of the Test Plan

The test plan has five components:

. . . . Engines, Fuels, and Emission Controls to be Tested
. . . . Matrix of Operating Conditions to be Tested
. . . . Pollutants to be Measured During Testing
. . . . Test Methods to Quantify Emissions
. . . . Prioritization

Each of these components is discussed in the sections that follow. A summary of each emissions test proposed is provided in the final section of this test plan.

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1.2 . . . . Emissions Testing Goals Identified by RICE Work Group

The RICE Work Group has identified the following possible goals for emissions testing under ICCR:

- determine the effectiveness of after-treatment control devices to reduce formaldehyde;
- determine the effectiveness of combustion modifications to reduce formaldehyde;
- determine typical emissions for engines throughout the operating range.

The Work Group has designed the emissions test plan principally around Goal #1, for the following reasons:

- Emissions data to demonstrate the effectiveness of possible MACT control devices for existing RICE is a data gap in the ICCR Emissions Database for RICE.
- Understanding of the effects of combustion modifications on HAPs is in its infancy, and would require a very extensive research program to identify potential control techniques, along with confirming testing.
- EPA has endorsed the use ICCR emissions testing dollars to achieve this goal.

V - 4

2.0 ENGINES, FUELS, AND EMISSION CONTROLS TO BE TESTED

2.1 Engines

The RICE Work Group recommends that a minimum of four engines be tested under ICCR. Each of the engines represents one of the four subcategories of engines that have been identified thus far by the Work Group (see **Table 1**). The subcategories have been determined principally based on the viability of possible MACT controls.

Table 1. Engines to be Tested

Engine to be Tested	Engine Subcategory
Clark TLA Turbocharged	2-stroke, gaseous fuel
Caterpillar 3500 Series Turbocharged	liquid-fuel
Waukesha 7042 GL Turbocharged	4-stroke, lean-burn, gaseous fuel
Ingersoll Rand KVG Naturally Aspirated	4-stroke, rich-burn, gaseous fuel

2.2 Fuels

Diesel fuel has been selected as the liquid fuel to be tested. The Work Group selected diesel fuel for the following reasons:

- Most stationary RICE that use liquid fuels use diesel.
- The efficiency of the control devices tested for diesel will be achievable by the other liquid fuels.

Natural gas has been selected as the gaseous fuel to be tested. The Work Group selected natural gas for the following reasons:

- Most stationary RICE that use gaseous fuels use natural gas.
- The efficiency of the control devices tested for natural gas will be achievable by the other gaseous fuels (propane, landfill gas, digester gas).

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2.3 Emission Controls

The Work Group recommends that the engines be tested with emissions control devices that have been identified as possible controls for the Maximum Achievable Control Technology (MACT) standard. To date, the Work Group has identified CO catalysts (carbon monoxide catalysts) as possible MACT controls for lean-burn engines. For rich-burn engines, the Work Group has identified non-selective catalytic reduction (NSCR) three-way catalysts as possible MACT controls. The Clark, Waukesha, and Caterpillar will be tested with CO (carbon monoxide) catalysts. The Work Group recommends that the Ingersoll Rand be tested with an NSCR three-way catalyst.

Engine to be Tested	Control Device
Clark TLA Turbocharged	carbon monoxide (CO) catalyst
Caterpillar 3500 Series Turbocharged	carbon monoxide (CO) catalyst
Waukesha 7042 GL Turbocharged	carbon monoxide (CO) catalyst
Ingersoll Rand KVA Naturally Aspirated	non-selective catalytic reduction (NSCR) three-way catalyst

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3.0 MATRIX OF OPERATING CONDITIONS TO BE TESTED

The Work Group recommends that the engines be tested throughout the entire operating envelope. The Work Group has developed a 16-point test matrix of operating conditions to be tested (see **Table 2**). The test matrix includes varied speed, torque, air-to-fuel ratio, air manifold temperature, jacket water temperature, timing, and combustion balance as applicable to the specific engine's operating envelope. The tests are organized as follows:

Four corners of the torque / speed envelope (runs 1-4)
Air-to-fuel ratio sensitivity (runs 1, 5-6)
High speed and low load (run 7)
Low speed and high load (run 8)
Air manifold temperature sensitivity (runs 1, 9-10)
Jacket water temperature sensitivity (run s1, 11-12)
Injection or spark timing sensitivity (runs 13-14)
Engine balance sensitivity (runs 1, 15-16)

An abbreviated matrix will apply to the engine subcategory for liquid fuels due to a reduced ability to vary parameters. Specific settings for the four engines selected are presented in the summary tables in the final section of this test plan.

The Work Group recommends that runs 1-14 be conducted with engine balance within the OEM (original equipment manufacturer) specification of good balance. The Work Group recommends that an engine "expert" be on-site during all testing to ensure that the engine is properly balanced and is being tested in a well-maintained condition. It is estimated that the test matrix will require approximately three days of emissions testing for each engine.

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Table 2. Matrix of Operating Conditions to be Tested

Run	Speed	Torque	Air to Fuel Ratio	Timing	Air Manifold Temperature	Jacket Water Temperature
1	H	H	N	S	S	S
2	H	L	N	S	S	S
3	L	L	N	S	S	S
4	L	H	N	S	S	S
5	H	H	L	S	S	S
6	H	H	H	S	S	S
7	H	L	H	S	S	S
8	L	H	L	S	S	S
9	H	H	N	S	L	S
10	H	H	N	S	H	S
11	H	H	N	S	S	L
12	H	H	N	S	S	H
13	H	H	N	L	S	S
14	H	H	N	H	S	S
15	H	H	N	S	S	S
16	H	H	N	S	S	S

*Notes:	H, L to be determined based on operating range and control flexibility.	H, L to be determined based on operating range and control flexibility.	N = Nominal reqd. to satisfy emissions H, L to be determined based on operating range and control flexibility.	S = Set point H, L to be determined based on operating range and control flexibility.

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4.0 POLLUTANTS TO BE MEASURED DURING TESTING

The Work Group recommends that emissions data for both hazardous air pollutants (HAPs) and criteria pollutants be collected during the emissions testing. The Work Group identified the principal pollutants that are reasonably anticipated to be emitted from the RICE.

Emissions data for the following criteria pollutants will be collected:

- carbon monoxide (CO)
- nitrogen oxides (NOx)
- total hydrocarbons (THC)
- particulate matter (PM)

Seven HAP pollutants are included in the test plan for all engines, regardless of fuel:

- BTEX (benzene, toluene, ethylbenzene, and xylene) and
- three aldehydes (formaldehyde, acetaldehyde, and acrolein).

Naphthalene, 1-3, butadiene, and PAHs are included for natural gas and diesel fuel. Metals are included for the diesel fuel tests. Chlorinated compounds that were originally included on the pollutant list for natural gas have been removed based on further review of the emissions test data in the ICCR Emissions Database and industry data related to the absence of chlorine in natural gas. A list of HAP pollutants for each proposed test are provided in the final section of this test plan.

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5.0 TEST METHODS TO QUANTIFY EMISSIONS DURING TESTING

The Work Group recommends the use of emissions test methods that will provide direct measurement of pollutants on-site. This approach to the test methods has been selected since it will be necessary to have on-site data to fully evaluate and conduct the matrix of engine operating conditions.

The Testing and Monitoring Work Group provided advice on the available methods to provide on-site data. Based on the T&M information, the aldehydes, BTEX compounds, n-Hexane, and 1-3, butadiene can be measured with test methods that will provide on-site data. There is no test method for naphthalene and PAHs that will provide on-site data. Therefore, the Work Group recommends that naphthalene and PAH data be collected for laboratory analysis.

The Work Group recommends that FTIR be used to collect data on aldehydes, NOx, and CO. The Work Group recommends that a portable GCMS be used to collect BTEX, n-Hexane, and 1-3, butadiene data. The Work Group recommends that metals for diesel fuel be evaluated through fuel testing.

The proposed test methods for each proposed emissions test are provided in the summaries of proposed emissions tests in the final section of this test plan.

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6.0 PRIORITIZATION

The Work Group recommends that priority be given to testing one engine from each subcategory that has been identified thus far by the RICE Work Group. The Work Group also recommends that priority be given to testing those emission control devices which have been identified thus far as possible controls for the Maximum Achievable Control Technology (MACT) standard. The four emission tests proposed in this test plan are consistent with this prioritization.

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7.0 SUMMARY OF PROPOSED EMISSIONS TESTS

7.1 Test #1: Clark TLA

Engine Subcategory:	**2-stroke, lean-burn, gaseous fuel**					
Engine to be Tested:	**Clark TLA Turbocharged**					
Fuel:	**Natural Gas**					
Control Device:	**Carbon Monoxide (CO) Catalyst**					
Pollutants to be Measured:	**Criteria Pollutants:** **NOx, CO, THC** Hazardous Air Pollutants: Benzene, Toluene, Ethylbenzene, and Xylene(s) Formaldehyde, Acetaldehyde, Acrolein 1-3, Butadiene, Naphthalene, PAHs					
Test Methods to be Used:	Method 18 / TO-14 with Portable GCMS for: Benzene, Toluene, Ethylbenzene, and Xylene(s) 1-3, Butadiene FTIR for: Formaldehyde, Acetaldehyde, Acrolein NOx, CO Method 429 for: Naphthalene, PAHs Method 25 for: **THC**					
Operating Conditions to be Tested:	Speed	Torque	Air-to-Fuel Ratio	**Timing**	Air Manifold Temp.	Jacket Water Temp.
Run 1	H	H	N	S	S	S
Run 2	H[1]	L[1]	N[1]	S[1]	S[1]	S[1]
Run 3	L[2]	L[2]	N[2]	S[2]	S[2]	S[2]
Run 4	L[1,2]	H[1,2]	N[1,2]	S[1,2]	S[1,2]	S[1,2]
Run 5	H	H	L	S	S	S
Run 6	H	H	H	S	S	S
Run 7	H[2]	L[2]	H[2]	S[2]	S[2]	S[2]
Run 8	L[2]	H[2]	L[2]	S[2]	S[2]	S[2]
Run 9	H	H	N	S	L	S
Run 10	H	H	N	S	H	S
Run 11	H	H	N	S	S	L
Run 12	H	H	N	S	S	H
Run 13	H	H	N	L	S	S
Run 14	H	H	N	H	S	S
Run 15	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
Run 16	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
	L[4]= 270 H[4]= 300	L[4,5] = 70 H[4,5] = 100	N[6] = 0.25 L[6] = 0.22 H[6] = 0.28	S = 4.5 L = 2 H = 7	S[7] = 100 L[7] = 80 H[7] = 120	S[8] = 150 L[8] = 140 H[8] = 160

Runs #2 and #4 are not applicable if the engine at the test site is running a pump or blower, since the torque absorbed by a pump or blower is generally determined by speed.
Runs #3, #4, #7, and #8 are not applicable if the engine at the test site is running a synchronous generator, since synchronous generators do not vary speed.
Same as Run #1 except with engine at limit of acceptable imbalance.
Depending on site and operating conditions, speed and torque range may vary.
If unit has ambient rating controls capability, high torque value may be up to 124%.
Fuel/air equivalence ratio for this two-stroke cycle engine is based on total airflow through engine, not trapped air.
JWT setpoint is based on normal operating practices, but may vary depending on site-specific conditions.
IT setpoint is based on pipeline quality natural gas. IT is a function of engine speed and AMT.

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7.2 Test #2: Caterpillar 3500 Series

Engine Subcategory:	**Liquid Fuel**					
Engine to be Tested:	**Caterpillar 3500 Series Turbocharged**					
Fuel:	**Diesel Fuel**					
Control Device:	**Carbon Monoxide (CO) Catalyst**					
Pollutants to be Measured:	**Criteria Pollutants:** **NOx, CO, THC, and PM** **Hazardous Air Pollutants:** **Benzene, Toluene, Ethylbenzene, Xylene(s)** **Formaldehyde, Acetaldehyde, Acrolein** **n-Hexane, 1-3, Butadiene, Naphthalene, PAHs** **Metals: Beryllium, Cadmium, Chromium, Lead, Manganese, Mercury, Nickel, Selenium**					
Test Methods to be Used:	**Method 18 / TO-14 with Portable GCMS for:** **Benzene, Toluene, Ethylbenzene, Xylene(s), n-Hexane, 1-3, Butadiene** **FTIR for:** **Formaldehyde, Acetaldehyde, Acrolein, NOx, and CO** **Method 429 for Naphthalene, PAHs** **Method 25A for THC** **EPA Method 5 for Particulate Matter** **Fuel Testing for Metals**					
Operating Conditions to be Tested:	Speed	Torque	Air-to- Fuel Ratio	**Timing**	Air Manifold Temp.	Jacket Water Temp.
Run 1	H	H	N	S	S	S
Run 2	H[1]	L[1]	N[1]	S[1]	S[1]	S[1]
Run 3	L[2]	L[2]	N[2]	S[2]	S[2]	S[2]
Run 4	L[1,2]	H[1,2]	N[1,2]	S[1,2]	S[1,2]	S[1,2]
Run 5	Not Applicable					
Run 6	Not Applicable					
Run 7	Not Applicable					
Run 8	Not Applicable					
Run 9	H	H	N	S	L	S
Run 10	H	H	N	S	H	S
Run 11	H	H	N	S	S	L
Run 12	H	H	N	S	S	H
Run 13	Not Applicable					
Run 14	Not Applicable					
Run 15	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
Run 16	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
	L[4,5] = 1000 H[4,5] = 1200	L[5] = 70 H[5] = 100	N = 0.68 (7.5% O2) L = 0.63 (8.5% O2) H = 0.74 (6.5% O2)	S = 28 L = 26 H = 30	S[6] = 130 L[6] = 120 H[6] = 140	S[7] = 160 L[7] = 155 H[7] = 165

Runs 2 and 4 are not applicable if the engine at the test site is running a pump or blower, since the torque absorbed by a pump or blower is generally determined by speed.
Runs 3, 4, 7, and 8 are not applicable if the engine at the test site is running a synchronous generator, since synchronous generators do not vary speed.
Same as Run #1 except with engine at limit of acceptable imbalance.
Depending on rating of separable compressor unit, speed values may vary between 700 – 1200 rpm.
Depending on site and operating conditions, speed and torque range may vary.
AMT totally depends on type of cooler configuration.
JWT setpoint is based on normal operating practices, but may vary depending on site-specific conditions.
IT setpoint is based on diesel fuel.

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7.3 Test #3: Waukesha 7042 GL

Engine Subcategory:	**4-stroke, lean-burn, gaseous fuel**
Engine to be Tested:	**Waukesha 7042 GL Turbocharged**
Fuel:	**Natural Gas**
Control Device: **Pollutants to be Measured:**	**Carbon Monoxide (CO) Catalyst** **Criteria Pollutants:** **NOx, CO, THC** **Hazardous Air Pollutants:** **Benzene, Toluene, Ethylbenzene, Xylene(s)** **Formaldehyde, Acetaldehyde, Acrolein** **1-3, Butadiene, Naphthalene, PAHs**
Test Methods to be Used:	**Method 18 / TO-14 with Portable GCMS for:** **Benzene, Toluene, Ethylbenzene, Xylene(s)** **1-3, Butadiene** **FTIR for:** **Formaldehyde, Acetaldehyde, Acrolein, NOx, CO** **Method 429 for Naphthalene, PAHs** Method 25A for THC

Operating Conditions to be Tested:	Speed	Torque	Air-to- Fuel Ratio	**Timing**	Air Manifold Temp.	Jacket Water Temp.
Run 1	H	H	N	S	S	S
Run 2	H[1]	L[1]	N[1]	S[1]	S[1]	S[1]
Run 3	L[2]	L[2]	N[2]	S[2]	S[2]	S[2]
Run 4	L[1,2]	H[1,2]	N[1,2]	S[1,2]	S[1,2]	S[1,2]
Run 5	H	H	L	S	S	S
Run 6	H	H	H	S	S	S
Run 7	H[2]	L[2]	H[2]	S[2]	S[2]	S[2]
Run 8	L[2]	H[2]	L[2]	S[2]	S[2]	S[2]
Run 9	H	H	N	S	L	S
Run 10	H	H	N	S	H	S
Run 11	H	H	N	S	S	L
Run 12	H	H	N	S	S	H
Run 13	H	H	N	L	S	S
Run 14	H	H	N	H	S	S
Run 15	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
Run 16	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
	L[4,5] = 1000 H[4,5] = 1200	L[4] = 70 H[4] = 100	N = 0.6 (9.8% O2) **L = 0.57** **(10.7% O2)** H = 0.65 (8.7% O2)	S[8] = 10 L[8] = 6 H[8] = 14	S[5] = 130 L[5] = 120 H[5] = 140	S[7] = 180

Runs 2 and 4 are not applicable if the engine at the test site is running a pump or blower, since the torque absorbed by a pump or blower is generally determined by speed.

Runs 3, 4, 7, and 8 are not applicable if the engine at the test site is running a synchronous generator, since synchronous generators do not vary speed.

Same as Run 1 except with engine at limit of acceptable imbalance.

Depending on rating of separable compressor unit, speed values may vary between 700 – 1200 rpm.

Depending on site conditions, speed and torque range may vary.

AMT setpoint depends on type of cooler configuration.

JWT setpoint is fixed control per thermostat. May not be changed by user-defined control setpoint.

IT setpoint is based on pipeline quality natural gas.

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7.4 Test #4: Ingersoll Rand KVG

Engine Subcategory:	**4-stroke, rich-burn, gaseous fuel**					
Engine to be Tested:	**Ingersoll Rand KVG Naturally Aspirated**					
Fuel:	**Natural Gas**					
Control Device:	**Non-Selective Catalytic Reduction (NSCR) 3-Way Catalyst**					
Pollutants to be Measured:	**Criteria Pollutants:** **NOx, CO, THC** **Hazardous Air Pollutants:** **Benzene, Toluene, Ethylbenzene, Xylene(s)** **Formaldehyde, Acetaldehyde, Acrolein** **1-3, Butadiene, Naphthalene, PAHs**					
Test Methods to be Used:	**Method 18 / TO-14 with Portable GCMS for:** **Benzene, Toluene, Ethylbenzene, Xylene(s)** **1-3, Butadiene** **FTIR for:** **Formaldehyde, Acetaldehyde, Acrolein, NOx, CO** **Method 429 for:** **Naphthalene, PAHs** Method 25A for THC					
Operating Conditions to be Tested:	Speed	Torque	Air-to- Fuel Ratio	**Timing**	Air Manifold Temp.	Jacket Water Temp.
Run 1	H	H	N	S	S	S
Run 2	H[1]	L[1]	N[1]	S[1]	S[1]	S[1]
Run 3	L[2]	L[2]	N[2]	S[2]	S[2]	S[2]
Run 4	L[1,2]	H[1,2]	N[1,2]	S[1,2]	S[1,2]	S[1,2]
Run 5	H	H	L	S	S	S
Run 6	H	H	H	S	S	S
Run 7	H[2]	L[2]	H[2]	S[2]	S[2]	S[2]
Run 8	L[2]	H[2]	L[2]	S[2]	S[2]	S[2]
Run 9	H	H	N	S	L	S
Run 10	H	H	N	S	H	S
Run 11	H	H	N	S	S	L
Run 12	H	H	N	S	S	H
Run 13	H	H	N	L	S	S
Run 14	H	H	N	H	S	S
Run 15	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
Run 16	H[3]	H[3]	N[3]	S[3]	S[3]	S[3]
	L[4] = 270 H[4] = 300	L[4] = 70 H[4] = 100	S = 1.00 L = 0.95 H = 1.05	S[7] = 15 L[7] = 12 H[7] = 18	See Note[5]	S[6] = 155 L[6] = 145 H[6] = 165

Runs 2 and 4 are not applicable if the engine at the test site is running a pump or blower, since the torque absorbed by a pump or blower is generally determined by speed.
Runs 3, 4, 7, and 8 are not applicable if the engine at the test site is running a synchronous generator, since synchronous generators do not vary speed.
Same as Run 1 except with engine at limit of acceptable imbalance.
Depending on site and operating conditions, speed and torque range may vary.
AMT totally dependent on ambient temperatures. 20 degree swing in temperature desirable for testing.
JWT setpoint is based on normal operating practices, but may vary depending on site-specific conditions.
IT setpoint is based on pipeline quality natural gas and may vary with certain ambient and operating parameters.

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ATTACHMENT VI
COMMENTS ON POLLUTANT LIST
PRESENTED BY LAURA KINNER

Comments on Pollutant Lists

presented to:

Reciprocating IC Engine Work Group
Durham, North Carolina

presented by:

Sam Clowney, Tennessee Gas Pipeline,
on behalf of the Emissions Subgroup

September 18, 1997

Overview of Comments

- 7 comments on pollutants received from members of ICCR outside RICE Work Group
- Only one provided a reference to data to support the comment (mercury)
- General sense in Subgroup that lists should not get longer -- if possible, should be shorter
- Preliminary response to comments prepared by Subgroup with assistance from Dr. Laura Kinner, Emissions Monitoring, Incorporated (EMI) and Dr. Bryan Willson, Colorado State University (CSU)

Comments Received & Preliminary Responses (1)

- All fuels:
  - Add criteria pollutants (Comment #3)
    - » *Added CO, NOx, THC, and PM (diesel only)*
  - Test fuels for anticipated inorganic HAPs by fuel testing (Comment #3)
    - » *Added fuel tests for metals from diesel fuel*
  - Compare lists to any future list of potential HAPs formed during combustion developed by the Coordinating Committee (Comment #2)

Comments Received & Preliminary Responses (2)

- Diesel Fuel:
  - Add all HAPs detected in tests for natural gas (Comment #2)
    - *No Additional Pollutants*
      - *All HAPs detected for natural gas on the diesel list, except chlorinated compounds -- chlorinated compounds for natural gas called into question*
      - Remove all Metals (Comment #7)
    - *Response not yet decided*
      - *Fuel testing could be used in lieu of stack testing*

Comments Received & Preliminary Responses (3)

- Digester Gas:
  - Add all HAPs detected in test for natural gas, except chlorinated compounds (Comment #5)
    - » *No Additional Pollutants*
      - *1,3-butadiene, Naphthalene, and PAHs only pollutants on natural gas list that are not on digester gas list -- 1,3-butadiene tested for multiple times and never detected -- if no 1,3-butadiene, reasonable to assume no naphthalene or PAHs*
  - Add Methanol (Comment #4)
    - » *No Additional Pollutants*
      - *Orange Co. tested for methanol in 1995, no methanol detected*
  - Add Chlorobenzene (Comment #2)
    - » *No Additional Pollutants*
      - *Of 10 tests for chlorobenzene, 9 times reported as non-detect*

Comments Received & Preliminary Responses (4)

- Landfill Gas:
  - Add Mercury (Comment #1)
    - » *Response not yet decided*
      - *Bryan Willson reviewing this issue for Subgroup*
  - Add all HAPs detected in tests for natural gas (Comment #2), except chlorinated compounds (#5)
    - » *Response not yet decided*
      - *1,3-butadiene, Naphthalene, and PAHs only pollutants on natural gas list that are not on digester gas list (except chlorinated compounds). No tests for 1,3-butadiene, Naphthalene or PAHs*
  - Add chlorinated compounds detected in tests for other fuels (Comment #2)
    - » *Response not yet decided*
      - 1,1,2,2-tetrachloroethane, chlorobenzene, ethyl chloride, methylene chloride, 1,4-dichlorobenzene (p), vinyl chloride

Comments Received & Preliminary Responses (5)

- Propane:
  - Add all HAPs detected in tests for natural gas (Comment #2), except chlorinated compounds (#5)
    - » Add pollutants (except chlorinated compounds)
      - 1,3-butadiene and PAHs only pollutants on natural gas list that are not on propane list (except chlorinated compounds) -- since Naphthalene detected for propane, 1,3-butadiene and PAHs may be present
      - Add PAH, since Naphthalene detected (Comment #2)
    - » Add pollutant
      - PAHs may be present since naphthalene detected

Comments Received & Preliminary Responses (6)

- Natural Gas:
  - Remove chlorinated compounds (Comment #6 & 7)
    - » Compounds removed
      - based on additional review of data in database, and industry information about absence of chlorine in natural gas, compounds removed -- source of chlorinated compounds likely laboratory contamination

Summary of Preliminary Response

- **Diesel Fuel:** no HAP pollutants added, fuel testing for metals, NOx, CO, THC, and PM added
- **Digester Gas:** no HAP pollutants added, NOx, CO, and THC added
- **Landfill Gas:** additional HAPs to be determined, NOx, CO, and THC added
- **Propane:** 1,3-butadiene and PAHs added, NOx, CO, and THC added
- **Natural Gas:** 4 chlorinated compounds removed, NOx, CO, and THC added

☆ Final response to comments will be circulated to Work Group and included in test plan as an appendix

ATTACHMENT VII
POPULATION SUBGROUP REPORT
PRESENTED BY WAYNE HAMILTON

Reciprocating Internal Combustion Engines Work Group

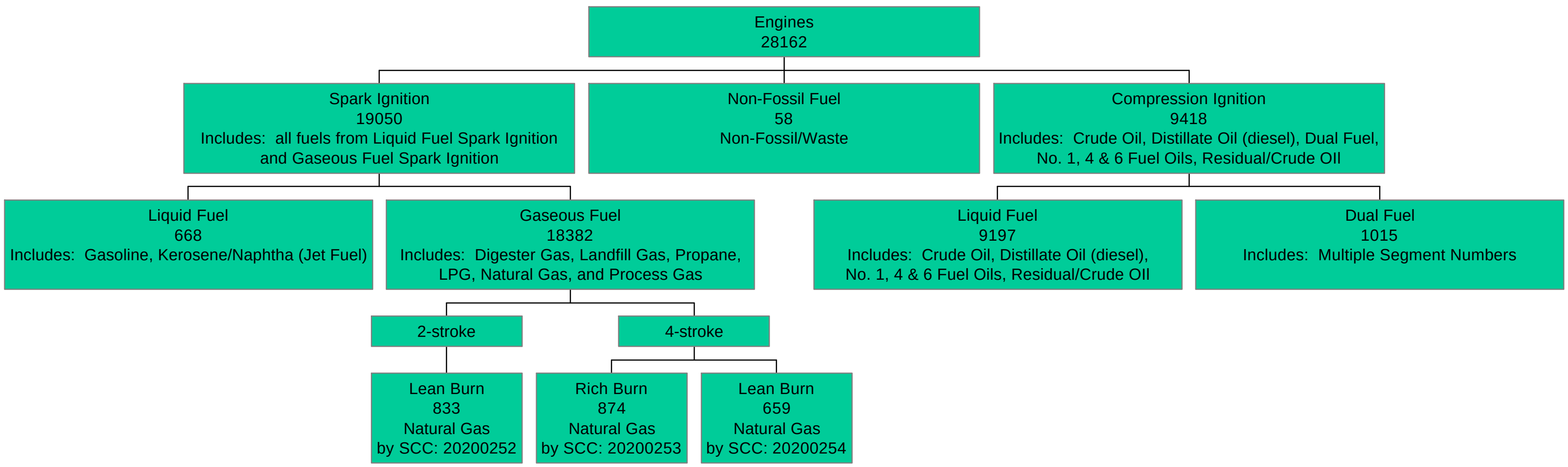
Population Database - Refinement

September 18, 1997

A) IC Engine Make and Model Information

B) Subcategory Tree

- Total number of engines: 28,162



C) Update SCCs Based on New Make and Model Information

D) Capacity Unit Conversion

- Convert engine size to a standard unit

  Engine size units provided in energy input units or power output units

  WG needs to get consensus on this issue.

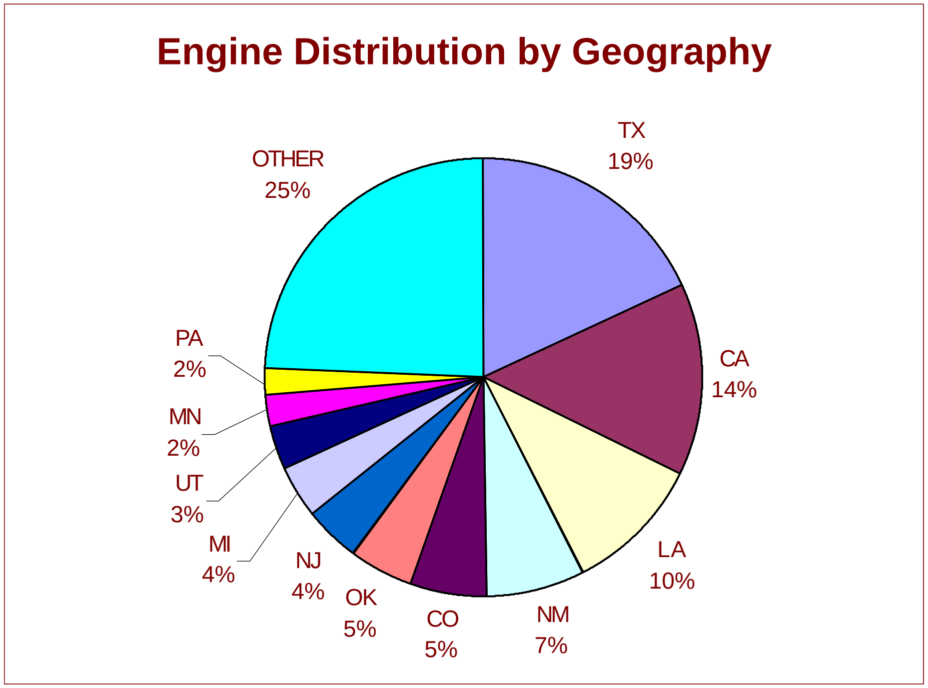
  From the 1993 ACT, the following efficiencies are provided;

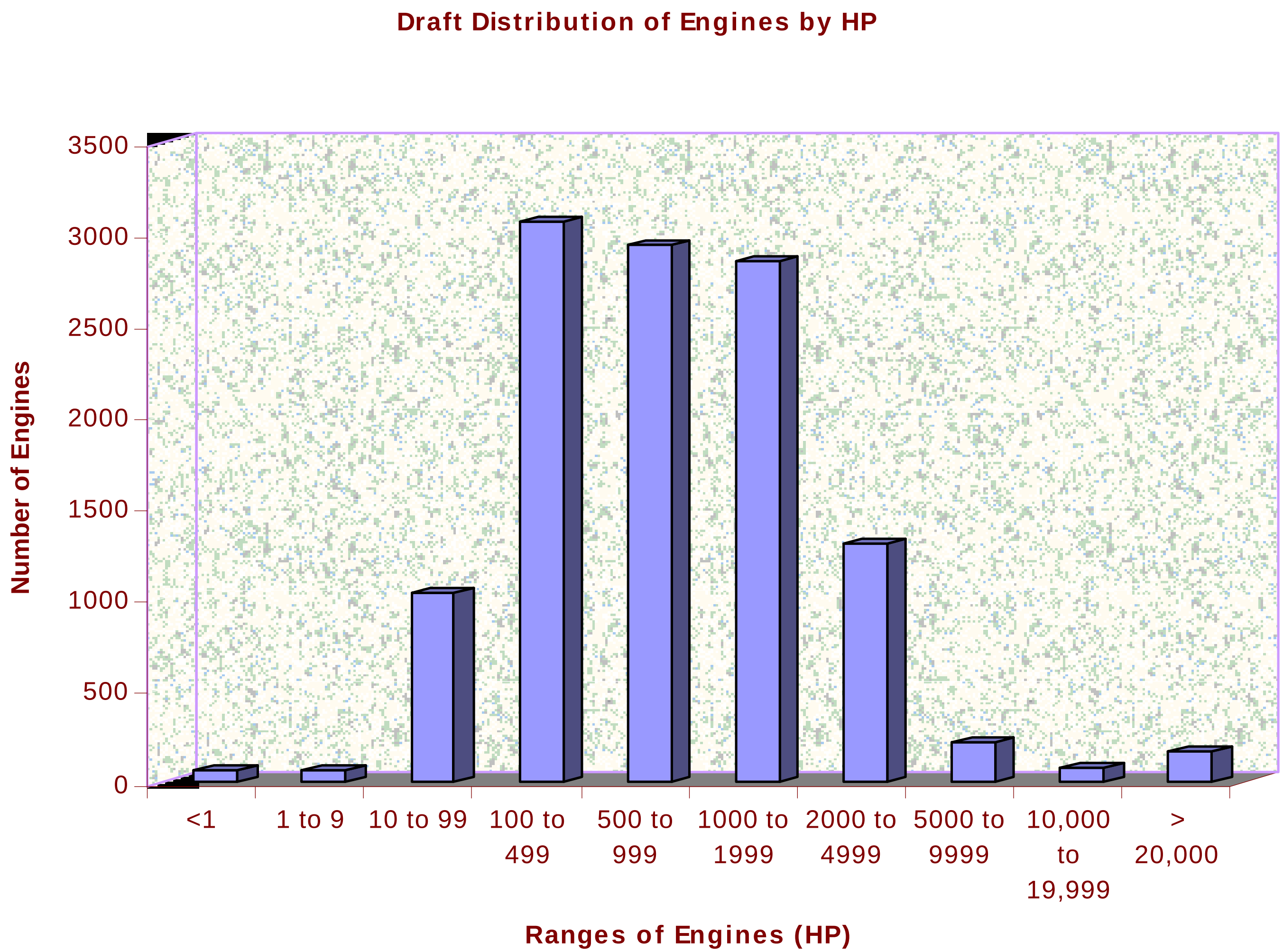
Rich-Burn SI Engines:	*34.4% (31 - 38)*
Lean-Burn SI Engines:	*33.8% (29 - 38)*
Diesel Engines:	*38.4% (38 - 41)*
Dual-Fuel Engines:	*37.6% (37 - 41)*

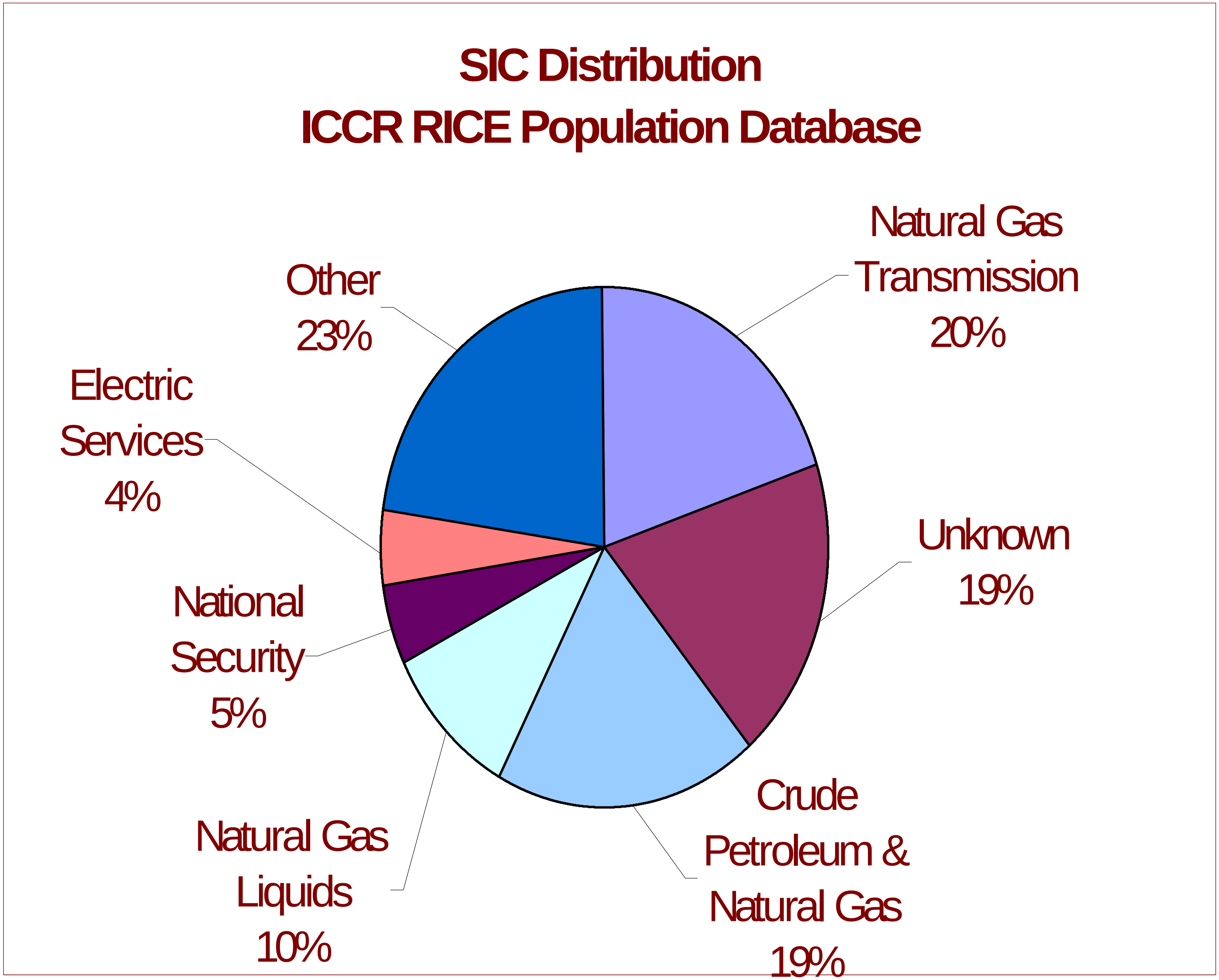
  WG member information reflect lower efficiencies:

2 Stroke SI Engines:	*28% (20 - 36)*
4 Stroke SI Engines:	*29% (21 - 35)*

E) Engine Distribution by Geography, HP and SIC




Draft Distribution of Engines by HP
Number of Engines
3500
3000
2500
2000
1500
1000
500
0
<1
1 to 9
10 to 99
100 to 499
500 to 999
1000 to 1999
2000 to 4999
5000 to 9999
10,000 to 19,999
> 20,000
Ranges of Engines (HP)


SIC Distribution
ICCR RICE Population Database
Natural Gas Transmission 20%
Unknown 19%
Crude Petroleum & Natural Gas 19%
Natural Gas Liquids 10%
National Security 5%
Electric Services 4%
Other 23%

F) Subcategory Statistical Representation

- How representative are the subcategorization data?
- Are the data adequately representative in order to extrapolate the rest of the engine population?

G) Use of Blanks in the Control Device Code Field

¨ Control Device Information Summary:

Criteria I: Only "000" considered as "No Equipment"

Criteria II: "000" or "Null" as "No Equipment"

- Notes:

  Need to check on some of the referenced control devices (e.g., bag filters for NG unit, catalytic reduction for 4 stroke lean burn engines)

G) Use of Blanks in the Control Device Code Field (cont'd.)

- Control Device Information Summary (cont'd):
- Top Eight States (68% of population)
  - Texas (18%) blanks = no control devices
  - California (14%) not a required field, therefore not reliable
  - Louisiana (10%) blanks = no control devices
  - New Mexico (7%) blanks = no control devices
  - Colorado (5%) blanks = no control devices
  - Oklahoma (5%) blanks = no control devices
  - New Jersey (4%) blanks = no control devices
  - Michigan (4%) blanks = no control devices (unconfirmed)

H) Benchmarking Data with Other Databases

- API information
- INGAA information

I) Summary and Action Items

ATTACHMENT VIII

TOPICS TO BE DISCUSSED AT THE SEPTEMBER 18 MEETING

POPULATION SUBGROUP

(All information should be considered in draft form)

OUTLINE OF POPULATION SUBGROUP INFORMATION
TO BE DISCUSSED AT
THE SEPTEMBER 18 RICE WORK GROUP MEETING

A) IC Engine Make and Model Information

Alpha-Gamma incorporated additional make and model information submitted by Mike Milliet, Vick Newsom, Don Dowdall and Bob Stachowicz into the current Make and Model Lookup table in the RICE Population database. The current numbers are as follows:

Populated Make and Model fields by number of engines: 3022 (10.7%)
Populated model, unpopulated make by number of engines: 86 (0.305%)
868 engines in Make and Model Lookup Table
503 of engines in database match with make and model in lookup table
544 of engines in database match with model in lookup table, but 28 of these makes don't match
Therefore, 516 engines match with model and unconflicting make

B) Subcategory Tree Based on New Information

Based on newly submitted make and model information, the engines are subcategorized as follows (number of engines is given in parentheses):

- All Engines (28162)
  - Spark Ignition (19050)
    - Liquid fuel (668)
    - Gaseous fuel (18382)
      - Two Stroke
        - Lean Burn (833)
      - Four Stroke
        - Lean Burn (659)
        - Rich Burn (874)
  - Compression Ignition (9418)
    - Liquid fuel (9197)
    - Dual fuel (1015)

C) Revise and Update SCCs based on new Make and Model information

Since new make and model information was obtained, additional parameters were known about hundreds of engines in the database. This allowed us to assign new SCCs, particularly to those engines which are now known as 2 or 4 stroke and rich or lean burn. This was performed in order to get a better data distribution for the proposed subcategories as well as to gain the ability to assign capacity conversion efficiencies, described below.

D) Run Code for Capacity Unit Conversion

A code was written to convert all engine operating capacities in the population database to horsepower. In the raw version 2 database, capacities were given in various units, including heat input units (MMBTU/hr, tons/hr, scfm, gal/yr) and power output units (HP, MW, boiler HP). For comparison purposes, there is a need to convert these units to a standard format. Horsepower was selected as the standard capacity unit. The 1994 ACT document was used as the basis for the capacity conversion. Alpha-Gamma proposes using the thermal efficiency averages pulled from the ACT document:

* Rich burn spark ignition: 34.4% efficient
* Lean burn spark ignition: 33.8%
* Diesel: 38.4%
* Duel Fuel: 37.6%

E) Develop Engine Distribution by Horsepower and Geography

Alpha-Gamma determined engine distributions by horsepower, geography, and SIC in order to better determine whether the database information is representative of the current industry. These tables and graphs are attached.

F) Identified Subcategory Statistical Representation

* Questions:
1. How representative is the subcategorization data?
2. Is the statistical sampling adequately representative to "ramp up" engine population?

* Answers:
1. Need statistical assistance and expertise
2. Use USEPA or industry statistician subcontractor to review the database

Since all ICCR Source Work Groups will be facing similar problems with statistical representation, the USEPA will be looking into providing assistance to review the statistical significance of the database. Wayne Hamilton will also contact Mark Dunn, Shell Statistician, to determine if he is available to review the USEPA database.

G) The Use of "Blank" Data Records in the “Control Device Code” field

The subgroup recommended that Alpha-Gamma contact two-thirds of the engines population in the database (top eight states) to understand the "blank" data records in the “Control Device Code” field. Alpha-Gamma has contacted state regulatory personnel for the eight states with the highest engine populations (representing 68% of the engines in the population database) in order to understand the "blanks" in database.

Results are as follows:

TOP EIGHT STATES (68% of population)

Texas:	18.12%	blanks equal no control devices	(4691/5104 are blank)
California:	14.06%	unknown (not a required field)	(2904/4007 are blank)
Louisiana:	10.29%	blanks equal no control devices	(1372/3016 are blank)
New Mexico:	7.27%	blanks equal no control devices	(1017/2049 are blank)
Colorado:	5.46%	blanks equal no control devices	(1345/1572 are blank)
Oklahoma:	4.87%	blanks equal no control devices	(323/1392 are blank)
New Jersey:	4.12%	blanks equal no control devices	(2/1377 are blank)
Michigan:	3.94%	blanks equal no control devices (unconfirmed)	(97/1245 are blank)

Control devices breakdown by subcategory are attached.

H) Benchmarking Data with API & INGAA

The population subgroup agreed to compare the results of the EPA ICCR RICE population database to other databases provided by WG members, as they become available. Mike Milliet plans to contact API about the use of the IC engine survey data as benchmark information by September 10, 1997.

Number of Engines by State

State Code	State Abbreviation	Number of Engines	Percent of Population
48	TX	5103	18.12%
06	CA	3960	14.06%
22	LA	2899	10.29%
35	NM	2046	7.27%
08	CO	1538	5.46%
40	OK	1372	4.87%
34	NJ	1160	4.12%
26	MI	1109	3.94%
49	UT	880	3.12%
27	MN	663	2.35%
42	PA	573	2.03%
56	WY	529	1.88%
17	IL	499	1.77%
20	KS	451	1.60%
31	NE	424	1.51%
29	MO	400	1.42%
55	WI	385	1.37%
51	VA	378	1.34%
54	WV	315	1.12%
01	AL	289	1.03%
04	AZ	285	1.01%
30	MT	262	0.93%
72	PR	260	0.92%
05	AR	260	0.92%
18	IN	204	0.72%

State Code	State Abbreviation	Number of Engines	Percent of Population
25	MA	190	0.67%
09	CT	174	0.62%
12	FL	170	0.60%
02	AK	147	0.52%
33	NH	146	0.52%
15	HI	139	0.49%
16	ID	133	0.47%
39	OH	111	0.39%
38	ND	108	0.38%
78	VI	86	0.31%
53	WA	78	0.28%
24	MD	74	0.26%
50	VT	68	0.24%
23	ME	52	0.18%
37	NC	50	0.18%
36	NY	41	0.15%
45	SC	32	0.11%
66	GU	31	0.11%
44	RI	26	0.09%
19	IA	23	0.08%
28	MS	15	0.05%
41	OR	7	0.02%
13	GA	6	0.02%
21	KY	5	0.02%
10	DE	3	0.01%
32	NV	2	0.01%
46	SD	1	0.00%
	Total Number of Engines:	**28162**	

2

Note: No engines are currently in the database for DC or TN. Tennessee has been contacted and has submitted additional engines which were previously missing.

Distribution of Engines by HP (Draft as of 9/10/97)

Ranges of HP	No. of Engines
<1	64
1 to 9	58
10 to 99	1039
100 to 499	3071
500 to 999	2941
1000 to 1999	2847
2000 to 4999	1301
5000 to 9999	218
10,000 to 19,999	80
20,000 to 2MM	171
TOTAL	**11790**

ENGINE DISTRIBUTION BY SIC

Corresponding Industry	Percentage
Natural Gas Transmission	20.12
Unknown/Multiples	18.86
Crude Petroleum & Natural Gas	18.62
Natural Gas Liquids	9.79
National Security	5.24
Electric Services	4.49
Other	22.88
	100

Spark Ignition Gaseous Fuels

Criteria I: Without blanks

Control Device Description	Count	Percentage
No Equipment	5987	83.40%
Catalytic Reduction	806	11.23%
Catalytic Afterburner	114	1.59%
Miscellaneous Control Devices	47	0.65%
Control of % 02 in Comb. Air	27	0.38%
Flaring	24	0.33%
Staged Combustion	24	0.33%
Direct Flame Afterburn	20	0.28%
Tray-Type Gas Absorption Column	17	0.24%
Vapor Recovery System	14	0.20%
Modif. Furnace/Burner Design	12	0.17%
Steam or Water Injection	12	0.17%
Mist Eliminator High Veloc.	8	0.11%
Mist Eliminator Low Veloc.	7	0.10%
Gas Scrubber, General	6	0.08%
Low Excess-Air Firing	6	0.08%
Electro. Prec. High Efficien.	5	0.07%
Ammonia Injection	4	0.06%
Dust Suppess--Water Spray	4	0.06%
Fabric Filter Low Temp	4	0.06%
Catal. Oxide.-Flue Gas Desulf.	3	0.04%
Lean Burn (includes Clean-Burn)	3	0.04%
Reduc. Combustion-Air Preheat	3	0.04%
Bottom Filling	2	0.03%
Centrif. Coll. Low Efficien.	2	0.03%
Electro. Prec. Low Efficien.	2	0.03%
Fabric Filter Med Temp	2	0.03%
Process Change	2	0.03%
Air injection	1	0.01%
Annular Ring Filter	1	0.01%
Cat. Afterburn-Heat Exch.	1	0.01%

Control Device Description	Count	Percentage
Chemical Oxidation	1	0.01%
Chemical Reduction	1	0.01%
Conversion to Variable Vapor Space Tank	1	0.01%
Electro. Prec. Med Efficien.	1	0.01%
Fabric Filter High Temp	1	0.01%
Flue Gas Recirculation	1	0.01%
Fuel-Low Nitrogen Content	1	0.01%
Multiple Cyclone W/O Fly Ash Reinjection	1	0.01%
Wet Scrubber High Efficien.	1	0.01%
Total (Without Blanks)	**7179**	

Spark Ignition Gaseous Fuels

Criteria II: With blanks

Control Device Description	Count	Percentage
No Equipment	17434	93.60%
Catalytic Reduction	806	4.33%
Catalytic Afterburner	114	0.61%
Miscellaneous Control Devices	47	0.25%
Control of % 02 in Comb. Air	27	0.14%
Flaring	24	0.13%
Staged Combustion	24	0.13%
Direct Flame Afterburn	20	0.11%
Tray-Type Gas Absorption Column	17	0.09%
Vapor Recovery System	14	0.08%
Modif. Furnace/Burner Design	12	0.06%
Steam or Water Injection	12	0.06%
Mist Eliminator High Veloc.	8	0.04%
Mist Eliminator Low Veloc.	7	0.04%
Gas Scrubber, General	6	0.03%
Low Excess-Air Firing	6	0.03%
Electro. Prec. High Efficien.	5	0.03%
Ammonia Injection	4	0.02%
Dust Suppess--Water Spray	4	0.02%
Fabric Filter Low Temp	4	0.02%
Catal. Oxide.-Flue Gas Desulf.	3	0.02%
Lean Burn (includes Clean-Burn)	3	0.02%
Reduc. Combustion-Air Preheat	3	0.02%
Bottom Filling	2	0.01%
Centrif. Coll. Low Efficien.	2	0.01%
Electro. Prec. Low Efficien.	2	0.01%
Fabric Filter Med Temp	2	0.01%
Process Change	2	0.01%
Air injection	1	0.01%
Annular Ring Filter	1	0.01%
Cat. Afterburn-Heat Exch.	1	0.01%

Control Device Description	Count	Percentage
Chemical Oxidation	1	0.01%
Chemical Reduction	1	0.01%
Conversion to Variable Vapor Space Tank	1	0.01%
Electro. Prec. Med Efficien.	1	0.01%
Fabric Filter High Temp	1	0.01%
Flue Gas Recirculation	1	0.01%
Fuel-Low Nitrogen Content	1	0.01%
Multiple Cyclone W/O Fly Ash Reinjection	1	0.01%
Wet Scrubber High Efficien.	1	0.01%
Total (With Blanks)	**18626**	

Spark Ignition Gaseous Fuels - Natural Gas : 2-Stroke and Lean Burn

Criteria I: Without blanks

Control Device Description	Count	Percentage
No Equipment	334	97.09%
Mist Eliminator High Veloc.	8	2.33%
Centrif. Coll. Low Efficien.	1	0.29%
Electro. Prec. High Efficien.	1	0.29%
Total (Without Blanks)	**344**	

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Spark Ignition Gaseous Fuels - Natural Gas : 2-Stroke and Lean Burn

Criteria II : With blanks

Control Device Description	Count	Percentage
No Equipment	825	98.80%
Mist Eliminator High Veloc.	8	0.96%
Centrif. Coll. Low Efficien.	1	0.12%
Electro. Prec. High Efficien.	1	0.12%
Total (With Blanks)	**835**	

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Spark Ignition Gaseous Fuels - Natural Gas : 4-Stroke and Lean Burn

Criteria I: Without blanks

Control Device Description	Count	Percentage
No Equipment	156	70.91%
Catalytic Reduction	53	24.09%
Miscellaneous Control Devices	4	1.82%
Staged Combustion	3	1.36%
Catalytic Afterburner	1	0.45%
Control of % 02 in Comb. Air	1	0.45%
Low Excess-Air Firing	1	0.45%
Modif. Furnace/Burner Design	1	0.45%
Total (Without Blanks)	**220**	

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Spark Ignition Gaseous Fuels - Natural Gas : 4-Stroke and Lean Burn

Criteria II: With blanks

Control Device Description	Count	Percentage
No Equipment	598	90.33%
Catalytic Reduction	53	8.01%
Miscellaneous Control Devices	4	0.60%
Staged Combustion	3	0.45%
Catalytic Afterburner	1	0.15%
Control of % 02 in Comb. Air	1	0.15%
Low Excess-Air Firing	1	0.15%
Modif. Furnace/Burner Design	1	0.15%
Total (With Blanks)	**662**	

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DRAFT ONLY: THIS INFORMATION IS BEING REVISED

Spark Ignition Gaseous Fuels - Natural Gas : 4-Stroke and Rich Burn

Criteria I: Without blanks

Control Device Description	Count	Percentage
Catalytic Reduction	163	47.94%
No Equipment	152	44.71%
Catalytic Afterburner	20	5.88%
Control of % 02 in Comb. Air	2	0.59%
Fabric Filter High Temp	1	0.29%
Miscellaneous Control Devices	1	0.29%
Modif. Furnace/Burner Design	1	0.29%
Total (Without Blanks)	**340**	

Spark Ignition Gaseous Fuels - Natural Gas : 4-Stroke and Rich Burn

Criteria II: With blanks

Control Device Description	Count	Percentage
No Equipment	697	78.76%
Catalytic Reduction	163	18.42%
Catalytic Afterburner	20	2.26%
Control of % 02 in Comb. Air	2	0.23%
Fabric Filter High Temp	1	0.11%
Miscellaneous Control Devices	1	0.11%
Modif. Furnace/Burner Design	1	0.11%
Total (With Blanks)	**885**	

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Spark Ignition Liquid Fuel

Criteria I: Without blanks

Control Device Description	Count	Percentage
No Equipment	293	91.56%
Catalytic Reduction	15	4.69%
Steam or Water Injection	6	1.88%
Catalytic Afterburner	4	1.25%
Ammonia Injection	2	0.63%
Total (Without Blanks)	**320**	

Spark Ignition Liquid Fuel

Criteria II: With blanks

Control Device Description	Count	Percentage
No Equipment	547	95.30%
Catalytic Reduction	15	2.61%
Steam or Water Injection	6	1.05%
Catalytic Afterburner	4	0.70%
Ammonia Injection	2	0.35%
Total (With Blanks)	**574**	